Statement of the Scientific Panel on Dietetic Products, Nutrition and Allergies on a request from the Commission related to dietary fibre

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(Request Nº EFSA-Q-2007-121)

(expressed on 6 July 2007 at its 17th plenary meeting corresponding to item 10.1 of the agenda)

BACKGROUND

In accordance with Article 29 (1)(a) and Article 31 of Regulation (EC) No. 178/2002, the Commission has requested the European Food Safety Authority (EFSA) to review the existing advice of the Scientific Committee for Food on population reference intakes for energy, nutrients and other substances with a nutritional or physiological effect in the context of a balanced diet which, when part of an overall healthy lifestyle, contribute to good health through optimal nutrition (EFSA-Q-2005-015a).

In the first instance, EFSA has been asked to provide advice on energy, macronutrients and dietary fibre. Following this first part of the task, EFSA has been asked to advise on population reference intakes of micronutrients in the diet and, if considered appropriate, other essential substances with a nutritional or physiological effect.

However, and as stated in the Commission request to EFSA (EFSA-Q-2005-015a), there is not a harmonized definition of dietary fibre at the European Community level. Within the international context of the Codex Alimentarius, there are ongoing discussions on the definition of dietary fibre.

As EFSA is in the process of preparing an opinion that will include dietary recommendations on dietary fibre for Europeans, the Commission requests EFSA's advice on the definition of dietary fibre, so as to be considered when preparing the Community position for the CCNFSDU meeting in November 2007.

COMMENT

1. Introduction

The term 'dietary fibre' was originally defined as 'that portion of food which is derived from cellular walls of plants which are digested very poorly by human beings' (Trowell, 1972). The recognition that polysaccharides added to foods, notably hydrocolloids, could have effects similar to those originating from plant cell walls led to a redefinition of dietary fibre to include 'polysaccharides and lignin that are not digested in the human small intestine'

(Trowell *et al.*, 1976). Since then, the definition of 'dietary fibre' has been much debated and related both to physiological considerations (i.e., digestion, absorption, health effects) and to the analytical methods that have been developed to quantify this chemically heterogeneous carbohydrate component in foods (FAO/WHO, 1998; Asp, 1995, 1996; Englyst and Hudson, 1996; Champ *et al.*, 2003; Englyst and Englyst, 2005).

Annex I shows the main types of food carbohydrates and their digestibility in the human small intestine under normal physiological conditions. Non-digestible carbohydrates are partially or totally fermentable by colonic microflora.

2. Physical-chemical characteristics and physiological effects of dietary fibre

Non-starch polysaccharides (NSP) are the main constituents of dietary fibre and include a host of different polymers, highly variable in terms of molecular size and structure, as well as in monomeric composition. Main classes of NSP are cellulose, hemicelluloses, pectins, and hydrocolloids. Due to their structural variability, different NSP may have very different physical-chemical properties, which are of key importance for their physiological effects. For example, cellulose is insoluble in water, whereas pectins and hydrocolloids, e.g. guar gum and mucilages, may form highly viscous water solutions. This applies as well to other non-digestible polysaccharides such as resistant starch, which is insoluble and indigestible due to its physical form or enclosure in cellular structures, or resistant oligosaccharides, which are readily soluble in water but do not form viscous solutions. The terms 'soluble' and 'insoluble' have been used in the literature to classify dietary fibre as viscous, soluble in water (e.g. pectins) or as water insoluble (e.g. cellulose) in an attempt to link different physical-chemical properties of fibre components to different physiological effects. However, the above classification is method-dependent, and water solubility does not always predict the physiological effects of dietary fibre. Therefore, FAO/WHO proposed the distinction between soluble and insoluble fibre to be phased out (FAO/WHO, 1998).

The interest of defining and quantifying dietary fibre in foods lies in the physiological effects that are associated with the consumption of that dietary component, which include decreased intestinal transit time and increased stools bulk, reducing blood total and/or LDL cholesterol levels, and reducing post-prandial blood glucose and /or insulin levels, among others (AFSSA 2002; NNR 2004; IoM 2005; GR 2006). These physiological effects of dietary fibre are distinct from those of digestible carbohydrates.

3. Definitions of dietary fibre in national and international recommendations of fibre intake for the healthy population

In national and international recommendations of dietary fibre intake, definitions of dietary fibre are generally in accordance with, and related to, methods of analysis approved by the Association of Official Analytical Chemists (AOAC). Definitions differ somewhat with respect to some minor components such as fibre of animal origin and certain fibre constituents manufactured either synthetically or by isolation from raw food material (Annex II).

The U.S. Food and Nutrition Board (FNB) defines "total dietary fibre" as the sum of "dietary fibre", consisting of non-digestible carbohydrates and lignin that are intrinsic and intact in plants, and "functional fibre", consisting of isolated, non-digestible carbohydrate components that have beneficial physiological effects in humans (IoM, 2005). The rationale behind this

differentiation is that epidemiological evidence links the intake of foods naturally high in dietary fibre, such as whole-grain cereals and some fruits and vegetables, to beneficial health effects, and that dietary fibre can be regarded as a marker of intake of such foods (IoM, 2005). The argument that the term "dietary fibre" should be restricted to non-starch polysaccharides of cell wall origin (Englyst and Englyst, 2005) has a similar rationale. Consequently, according to the FNB, documentation on the beneficial effects of added, functional fibre is required for inclusion in 'total dietary fibre'.

The Panel notes that a main problem in making this differentiation in practice is that no analytical method differentiates between "dietary fibre" and "functional fibre" once they occur mixed in a food product, and similarly, that NSP from plant cell walls cannot be differentiated from added NSP with similar monomeric composition.

4. Definition of dietary fibre in setting Population Reference Intakes for Europeans

Given the key importance of digestibility in the small intestine for the nutritional effects of carbohydrates in humans, the Panel recommends that dietary fibre should include all non-digestible carbohydrates. This includes non-starch polysaccharides, analytically resistant starch, resistant oligosaccharides (restricted to oligosaccharides with three or more monomeric units and polysaccharides) and other non-digestible, but quantitatively minor components that are associated with dietary fibre polysaccharides, especially lignin (Cho *et al.*, 1997; FAO/WHO, 1998; AACC, 2001; AFSSA, 2002; NNR, 2004; GR, 2006). This definition is in accordance with the proposal for a CODEX definition of dietary fibre currently under discussion (Codex, 2006).

Therefore, for the purpose of this Statement, dietary fibre is defined as non-digestible carbohydrates plus lignin. The Panel considers that the main types of total dietary fibre are:

- Non-starch polysaccharides – cellulose, hemicelluloses, pectins, hydrocolloids (i.e., gums, mucilages, β-glucans).
- Resistant oligosaccharides – fructo-oligosaccharides (FOS), galacto-oligosaccharides (GOS), other resistant oligosaccharides.
- Resistant starch – consisting of physically enclosed starch, some types of raw starch granules, retrograded amylose, chemically and/or physically modified starches.
- Lignin naturally associated with the dietary fibre polysaccharides.

5. Methods of analysis

Current enzymatic gravimetric or enzymatic chemical methods for dietary fibre cover NSP, analytically resistant starch and lignin. However, given that dietary fibre is a mixture of chemically heterogeneous carbohydrate components, several analytical methods are currently required to measure all fractions of dietary fibre. On one hand, methods measuring NSP alone (Englyst and Hudson, 1996) give lower estimates than methods for total dietary fibre in foods containing resistant starch, resistant oligosaccharides and/or lignin, e.g. whole-grain flour and cereals processed in a way that generates resistant starch. On the other hand, methods determining dietary fibre including resistant starch measure the fraction resistant to the enzymes used in the assay, which includes mainly retrograded amylose. Finally, resistant oligosaccharides and inulin are not included in any of the current methods for total dietary

fibre, and therefore need to be measured separately and subsequently added to the total fibre estimate (Cho *et al.*, 1997; Champ *et al*., 2003).

For practical purposes, it would be advisable that analytical methods could actually correspond better to the physiologically resistant starch present in foods (Asp, 1996; Champ *et al.*, 2001 and 2003) and that a single assay could be used to quantify all components of dietary fibre.

CONCLUSION

Intake of dietary fibre has a number of physiological effects in humans, e.g. decreased intestinal transit time, increased stools bulk, reduction of blood total and/or LDL cholesterol levels, and reducing post-prandial blood glucose and/or insulin levels. These effects vary depending on fibre component.

The definition of dietary fibre should include all carbohydrate components occurring in foods that are non-digestible in the human small intestine. This includes non-starch polysaccharides, resistant starch, resistant oligosaccharides with three or more monomeric units, and other non-digestible, but quantitatively minor components when naturally associated with dietary fibre polysaccharides, especially lignin.

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ANNEX I

Main types of carbohydrates (Adapted from Asp, 1996).

Class (DP[1])	Sub-group	Components	Monomers	Digestibility [2]
Sugars (1-2)	Monosaccharides	Glucose		+
		Galactose		+
		Fructose		+
	Disaccharides	Sucrose	Glu, Fru	+
		Lactose	Glu, Gal	+ (–) [3]
		Trehalose	Glu	+
		Maltose	Glu	+
Oligosaccharides (3-9)	Malto-oligo-saccharides	Maltodextrins	Glu	+
	Other oligo-saccharides	α-Galactosides (GOS)	Gal, Glu	–
		Fructo-oligo-saccharides (FOS)	Fru, Glu	–
		Polydextrose (PDX)	Glu	–
		Resistant dextrins	Glu	–
Polyols	Maltitol, sorbitol, xylitol, lactitol			+ –
Polysaccharides (>9)	Starch	Amylose	Glu	+ (–)
		Amylopectin	Glu	+ (–)
		Modified starch	Glu	+/ –
		Resistant starch	Glu	+/ –
		Inulin	Fru	–
	Non-starch poly-saccharides	Cellulose Hemicelluloses	Glu	–
		Pectins Hydrocolloids, e.g. gums, mucilages, β-glucans	Variable Uronic acids Variable	– – –
Related substance		Lignin		–

[1] DP = Degree of polymerisation
[2] Denotes digestibility in the human small intestine (+ digestible, , + (–) mainly digestible,+/- partly digestible, – non-digestible)
[3] Lactose is poorly digested by individuals with low intestinal lactase activity
Fru = Fructose, Glu = Glucose, Gal = Galactose

ANNEX II

Definitions of dietary fibre in dietary recommendations of fibre intake

Body	Definition
Codex proposal, Alinorm 06/29/26	Dietary fiber means carbohydrate polymers[1] with a degree of polymerisation (DP) not lower than 3 which are neither digested nor absorbed in the small intestine. DP not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture. Dietary fibre consist of one or more of: - Edible carbohydrate polymers naturally occurring in the food as consumed, - Carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means, - Synthetic carbohydrate polymers Properties: Dietary fiber generally has properties such as: • Decrease intestinal transit time and increase stools bulk • fermentable by colonic microflora • Reduce blood total and/or LDL cholesterol levels • Reduce post-prandial blood glucose and /or insulin levels. [1] When derived from a plant origin, dietary fibre may include fractions of lignin and/or other compounds when associated with polysaccharides in the plant cell walls and if these compounds are quantified by the AOAC gravimetric analytical method for dietary fiber analysis : Fractions of lignin and the other compounds (proteic fractions, phenolic compounds, waxes, saponins, phytates, cutin, phytosterols, etc.) intimately "associated" with plant polysaccharides are often extracted with the polysaccharides in the AOAC 991.43 method. These substances are included in the definition of fibre insofar as they are actually associated with the poly- or oligo-saccharidic fraction of fibre. However, when extracted or even re-introduced into a food containing non digestible polysaccharides, they cannot be defined as dietary fibre. When combined with polysaccharides, these associated substances may provide additional beneficial effects.
GR, 2006	Carbohydrates, compounds analogous to carbohydrates, and lignin and related substances that are not digested or absorbed in the human small intestine. These include: • Polysaccharides other than starch, and non-digestible oligosaccharides: e.g. cellulose, hemicelluloses such as arabinoxylans, arabinogalactans and xyloglucans, pectin, fructans and some oligosaccharides (inulin, fructo-oligosaccharides, oligofructose), galacto-oligosaccharides and xylo-oligosaccharides, gums and mucilages (for some population groups: lactose) • Compounds analogous to carbohydrates: indigestible dextrins (mainly from potatoes and maize), synthetic carbohydrates and their derivatives, polydextrose, methylcellulose, hydroxypropyl methylcellulose, etc. indigestible starch • Lignin • Substances that occur in products containing lignin or polysaccharides other than starch: wax, cutin, saponins, suberins, tannins

Body	Definition
IoM 2005	Dietary fiber: non-digestible carbohydrates and lignin that are intrinsic and intact in plants, e.g. cellulose, pectin, gums, hemicelluloses, b-glucans, and fibers contained in oat and wheat bran, plant carbohydrates that are not recovered by alcohol precipitation (e.g. inulin, oligosaccharides, and fructans), lignin, and some resistant starch. Excluded are non-digestible mono- and disaccharides and polyols, some resistant starch, non-digestible animal carbohydrates. Functional fiber: isolated, non-digestible carbohydrate components that have beneficial physiological effects in humans. May be isolated or extracted using chemical, enzymatic, or aqueous steps. Synthetically manufactured (DP $\geq$3) or naturally occurring isolated oligosaccharides and manufactured resistant starch are included. Naturally occurring polysaccharides or oligosaccharides usually extracted from their plant source that have been modified (e.g. to a shorter polymer length or to a different molecular arrangement) and animal derived non-digestible carbohydrates are included. Excluded are non-digestible mono- and disaccharides and polyols, some resistant starch, non-digestible animal carbohydrates. Total dietary fiber: sum of Dietary and Functional fiber
NNR 2004	Dietary fiber recommendation refers to dietary fiber naturally occurring in plant foods as measured by AOAC methods for total dietary fiber.
AFSSA 2002	Dietary fibre consists of: • Carbohydrate polymers (Polymerisation Degree (PD) > 3) of plant origin, which may or may not be associated in the plant with lignin or other non-carbohydrate components (polyphenols, waxes, saponins, cutin, phytates, phytosterols, etc). or • Carbohydrate polymers (PD > 3), processed (by physical, enzymatic or chemical means) or synthetic, included in the attached list whose contents may change on the basis of AFSSA recommendations. In addition, dietary fibre is neither digested not absorbed in the small intestine. It has at least one of the following properties: • Increase stools production • Stimulate colonic fermentation • Reduce pre-prandial cholesterol levels • Reduce post-prandial blood sugar and/or insulin levels.
DACH 2000	Dietary fiber comprises those components of vegetable food which are not degraded by physiological enzymes of the human gastrointestinal tract. Dietary fiber, except for lignin, stands for indigestible carbohydrates such as cellulose, hemicellulose, pectin, etc. Resistant starch and indigestible oligosaccharides such as oligofructose and oligosaccharides of the raffinose family (raffinose, stachyose, verbascose in pulses) are included.
UK (DoH,1991)	NSP (non alpha-glucan polysaccharides): cellulose, non-cellulose polysaccharides (pectins, glucans, arabinogalactans, arabinoxylans, gums, mucilages, inulin, guar, chitin)